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IMPACTS OF SKID ROAD CONSTRUCTION ON SOIL EROSION IN JOZANKEI NATIONAL FOREST, JAPAN

In this study, we examine the effect of skid trail construction on soil erosion in the selective cutting operation in compartment 2248, Jozankei National Forest, Hokkaido, Japan. Field surveys in the site show that the rainfall intensity is the primary control factor for the surface runoff on the skid trail. However, it is likely that the control factor of the surface runoff is rainfall intensity in the 1st year after cutting operation. The soil loss by surface wash is higher than by rill/gulley erosion. But it became lower mainly because the surface wash loss got lower. There is a relation that the longer the surface runoff on skid trail, the bigger the size of rill/gulley. The initial soil cut for skid trail construction is very large, and can contribute significantly to soil erosion. Skid trail management should approach the erosion problem through careful planning and by devising adequate construction standards.

Keywords: Soil erosion, Surface runoff, Skid trail, Rill/gulley, Soil cut

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Вплив спорудження трелювальних волоків на ерозію ґрунту в Джозанкейському національному лісі, Японія

Ми оцінювали вплив спорудження трелювальних волоків на ерозію ґрунту під час вибіркових рубань в кварталі 2248, Джозанкейський національний ліс, Хоккайдо, Японія. Польові обстеження показали, що інтенсивність опадів є точним показником для оцінки поверхні стоку на трелювальних волоках. Однак, ймовірно, що цей показник є коректним тільки в перший рік після рубання. Втрати ґрунту шляхом поверхневого змивання є вищими, чим потокова ерозія. Але потім ці втрати спадають із-за зменшення поверхні змивання. Більша поверхня стоку відповідає більшим розмірам водних потоків на трелювальному волоці. Перше зрізання ґрунту під час спорудження трелювального волоку є дуже великим і може приводити до значної ерозії ґрунту. При спорудженні трелювальних волоків повинні враховуватися проблеми ерозії ґрунту шляхом їх екологічнобезпечного планування з використанням відповідних стандартів.

Ключові слова: ерозія ґрунту, поверхня стоку, трелювальний волок, потік, зрізання ґрунту

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1. Introduction

There is an increasing public concern about the forests mainly for protecting environment. In productive forests the sustainability for the environment is often questioned because of its cost oriented logging practices. Especially the construction of skid trails in natural forests can be a major issue because skid trails are usually constructed at low cost and below standards, and rarely maintained properly once the harvesting is finished.

Hydraulic excavators are commonly used for the construction, and because of its earth-working feature, i.e. powerful in cutting, but poor in carrying; large amounts of unstable cut soil are left as side-casting on the fill slope after construction. This unbounded or remoulded soil can be easily eroded by rain drop impact, carried by groundwater flow and transported quickly into streams during flash floods. The surfaces of skid trails are compacted by passage of bulldozers with logs, and have limited infiltration capacity. This results in the formation of rills and gullies on the trails that wears surface soil, and creates pathways for eroded sediment to get delivered to the stream system. Also, the road surfaces remain very hard, dry and bare for a long time; it is difficult for vegetation to recover on such surfaces.

In this study, we would like to examine the effect of skid trail construction on soil erosion in a selective cutting operation in compartment 2248, Jozankei National forest, Hokkaido, Japan.

2. Study site and logging activities

The study site is located in compartment 2248 (latitude: 42°57' N, longitude: 141°10' E) in the Jozankei National forest, Hokkaido, Japan, 30 km south of Sapporo city with elevation ranging from 400 to 600 m. It has a northwestern aspect with slope gradient ranging 10° to 30°. The forest type is mixed conifer hardwood natural forest with the dominant species of *Picea jezoensis*, *Abies sachalinensis*, *Quercus mongolica*, etc.

In Jozankei National Forest, selective cutting has been used to manage the forest since 1969, and a dense forest road network (46.7 m per ha in the southern part of the forest) has been established. It also served as a watershed protection forest for the Sapporo, mega city with the population of 1.8 million.

In the study site the skid trail was constructed by a hydraulic excavator in December 2001, and the selective cutting was performed with D5 bulldozers in January 2002. The ground was covered by snow about 1.5 m depth throughout the operation period.

3. Methods

3.1. The erosion plots:

Two plots on the skid trail where the trail is constructed on a side slope by earthwork were selected for the erosion study. The average width (road width), horizontal distance, and inclination of both plots are 3.18 m, 25 m, 17.1-25.7 deg for 1st plot and 2.8 m, 80 m, 19.6-28.9 deg for 2nd plot respectively. The plots are adjoining each other, and 1st plot is located in the upper part.

3.2. Data collection:

We have collected the following data during no snow seasons for two years after the cutting operation (June-September 2002 and 2003): (1) Rainfall was measured by rain gauge set in the study site. (2) The surface runoff on the skid trail was observed visually during heavy rain events in 2002, and was measured by partial flow meter at the low end of plot 2 in 2003. (3) The volume of soil eroded from surface of skid trail (excluding rills and gullies). It was estimated from the height of soil pedestals preserved on road shoulders in 2002, and by cross-section survey at 5m intervals in 2003. (4) The volume of soil eroded from rills and gullies is estimated. We measured width and depth of the rills/gullies at every 5 m along the sinuous length, and calculated erosion volume from the cross-sectional area of each rill/gully segment. (5) The volume of soil cut by skid trail construction in plot 2. It was estimated by surveying the points in cross-sections at 5m intervals to determine the area of the cross section.

4. Results and Discussions

4.1. The surface runoff on the skid trail:

During measurement period (100 days) in 2002, 410 mm rainfall was gauged. According to the visual observation of the surface runoff on the skid trail, the runoff was occurred only when the rainfall intensity was relatively high, i.e., no runoff exists when the rainfall was 5 mm/hr, but it comes up when it was 14 mm/hr.

In 2003 the total rainfall gauged was 325 mm. We measured the surface runoff, and observed that the runoff comes up at almost all rainfall event with the intensity more than 1mm/hr (Figure 1). It is likely that other factors varied during 1st and 2nd years, probably soil physical properties. e.g., infiltration rate, particle size on road surface, and so on, are also controlling the surface runoff.

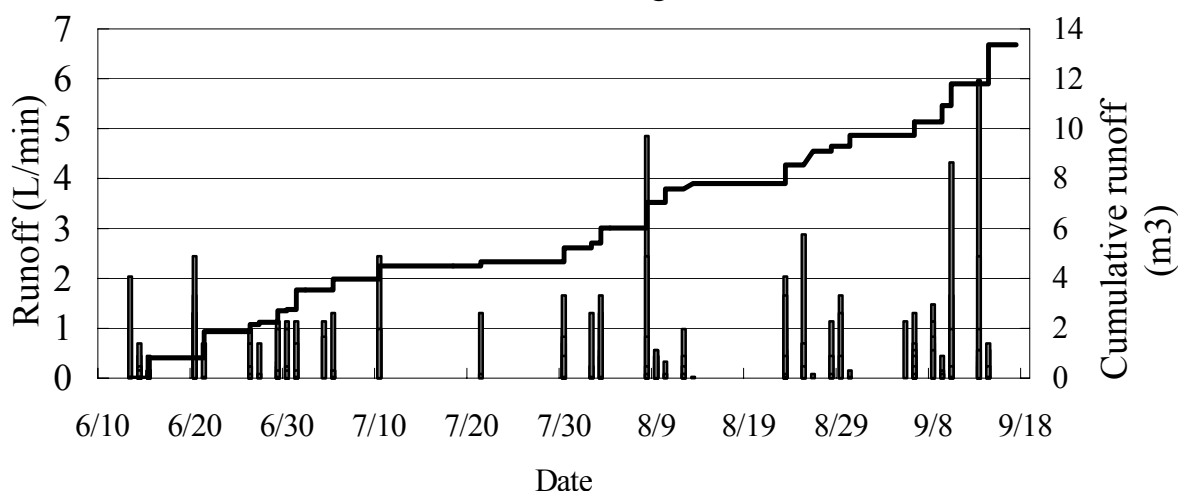


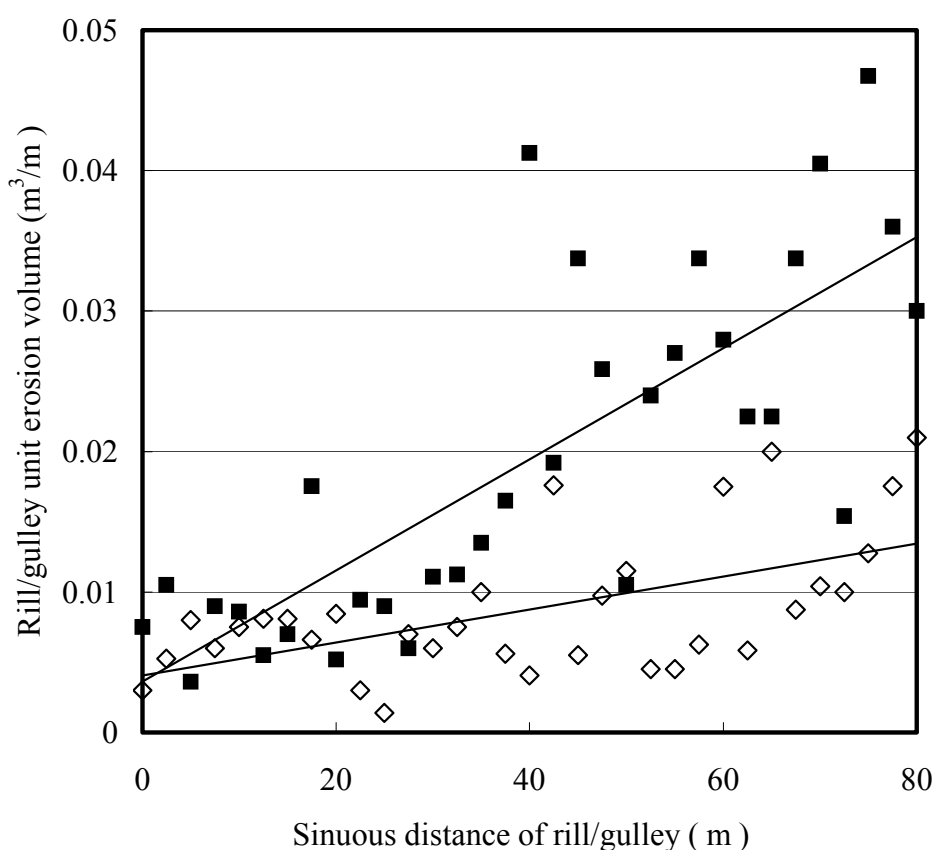
Figure 1. Diagram showing the surface runoff and hourly rainfall

4.2. The volume of soil eroded from the skid trail

The volume of soil eroded from surface of skid trail is summarized in Table 1. The unit erosions per m^2 in plot 1 and plot 2, which is equivalent to the average height of eroded soil, are $0.026 \text{ m}^3 \text{ m}^{-2}$, $0.013 \text{ m}^3 \text{ m}^{-2}$ respectively. The soil loss by surface wash is higher than by rill/gulley erosion, and the loss in 2002 (1st year) is higher than that in 2003. It is likely that the loss by surface wash is getting much lower in 2nd year, but the rill/gulley erosion seems to be remain similar level in 2nd year.

Table 1. Summary of The volume of soil eroded from surface of skid trail

		Jun - Sep 2002	Jun- Sep 2003
Total rain fall		410mm	325mm
Surface wash	(m ³)	4.18	1.80
Rill/Gulley erosion	(m ³)	1.56	1.14
Total in Plot 2	(m ³)	5.74	2.92
Unit erosion	(m ³ /m)	0.072	0.037
Erosion per unit area	(m ³ /m ²)	0.026	0.013

**Figure 2. Diagram showing the relationship between sinuous distance and erosion volume of rills/gullies**

There is linear correlation between the sinuous distance of rills/gullies and the rill/gully erosion volume (Figure 2). The Diagram shows a linear increase in erosion volume in longer rills/gullies. This means that the longer the surface runoff on skid trail, the higher the unit erosion of the rill/gulley, i.e., the size of rill/gulley is bigger.

4.3. The amount of soil cut by road construction

The mass of soil cut by the skid trail construction is left as side casting soils mostly on the fill slope, and some at the bottom of the cut slope without compaction for stabilization. There are no features like the side drain, cross drain, cross slope, and fill road surface. The chance of the soil entering the stream system is likely to increase if the slope is steep. Therefore the initial soil cut for such skid trail

constructions can contribute significantly to soil erosion. Especially when the skid trail is on the side slope, the amount of soil produced by the earthwork increases according to the gradient of slope.

The total soil cut volume per 80 meters is 95.76 m^3 ($1.20 \text{ m}^3/\text{m}$) which means the amount is more than 16 times bigger than the volume of erosion in 2002, and 35 times bigger than that of 2003.

This result shows that for reducing the erosion we have to be more careful about the cut soil produced by road constructions. However, the erosion on road surface is also fundamental because of its continuity and role for carrying the eroded soil.

5. Conclusion

According to the erosion survey on the skid trail, it was found that: (1) The rainfall intensity is the primly control factor for the surface runoff on the skid trail. However, it is likely that the control factor of the surface runoff is rainfall intensity in the 1st year after cutting operation. (2) The soil loss by surface wash is higher than by rill/gulley erosion. The erosion in 2nd year became lower mainly because the surface wash loss got lower. (3) There is a relation that the longer the surface runoff on skid trail, the bigger the size of rill/gulley. (4) The initial soil cut for skid trail construction is very large, and can contribute significantly to soil erosion.

It should be noted that skid trail management should approach the erosion problem through careful planning and by devising adequate construction standards.

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